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Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

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Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

Abstract

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2018, N applied alone increased yields by 76 bu/a, whereas P applied alone increased yields up to 17 bu/a. Nitrogen and P applied together increased yields up to 169 bu/a which is 26 bu/a more than the 10-year average of 143 bu/a. Application of 120 lb/a N (with highest P rate) produced 97% of maximum yield in 2018, which is slightly greater than the 10-year average. Application of 80 instead of 40 lb P₂O₅/a increased average yields 9 bu/a. Average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P₂O₅/bu). At the highest N and P rate, apparent fertilizer nitrogen recovery in the grain (AFNRg) was 43% and apparent fertilizer phosphorus recovery in the grain (AFPRg) was 62%.

Keywords

nitrogen fertilization, phosphorus fertilization, irrigated corn, long-term fertility, nutrient removal

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Cover Page Footnote

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Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Corn

A.J. Schlegel and H.D. Bond

Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2018, N applied alone increased yields by 76 bu/a, whereas P applied alone increased yields up to 17 bu/a. Nitrogen and P applied together increased yields up to 169 bu/a which is 26 bu/a more than the 10-year average of 143 bu/a. Application of 120 lb/a N (with highest P rate) produced 97% of maximum yield in 2018, which is slightly greater than the 10-year average. Application of 80 instead of 40 lb P_2O_5 /a increased average yields 9 bu/a. Average grain N content reached a maximum of 0.6 lb/bu while grain P content reached a maximum of 0.15 lb/bu (0.34 lb P_2O_5 /bu). At the highest N and P rate, apparent fertilizer nitrogen recovery in the grain (AFNR_g) was 43% and apparent fertilizer phosphorus recovery in the grain (AFPR_g) was 62%.

Introduction

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and potassium (K) fertilization. The study is conducted on a Ulysses silt loam soil with an inherently high K content. No yield benefit to corn from K fertilization was observed in 30 years, and soil K levels remained high, so the K treatment was discontinued in 1992 and replaced with a higher P rate.

Procedures

This field study is conducted at the Tribune Unit of the Kansas State University Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a without P and K; with 40 lb/a P_2O_5 and zero K; and with 40 lb/a P_2O_5 and 40 lb/a K_2O . The treatments were changed in 1992; the K variable was replaced by a higher rate of P (80 lb/a P_2O_5). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids [DeKalb 61-69 (2009), Pioneer 1173H (2010), Pioneer 1151XR (2011), Pioneer 0832 (2012-2013), Pioneer 1186AM (2014), Pioneer 35F48 AM1 (2015), Pioneer 1197 (2016), and Pioneer 0801 (2017-2018)] were planted at about 32,000 seeds/a in late April or early May. Hail damaged the 2008, 2010, and 2017 crops. The corn is irrigated to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 15.5% moisture. Grain samples were collected at

harvest, dried, ground, and analyzed for N and P concentrations. Grain N and P content (lb/bu) and removal (lb/a) were calculated. Apparent fertilizer N recovery in the grain ($AFNR_g$) was calculated as N uptake in treatments receiving N fertilizer minus N uptake in the unfertilized control divided by N rate. The same approach was used to calculate apparent fertilizer P recovery in the grain ($AFPR_g$). Grasshoppers were treated by aerial application of insecticide.

Results

Corn yields in 2018 were 15% higher than the 10-year average (Table 1). Nitrogen alone increased yields 76 bu/a, whereas P alone increased yields 17 bu/a. However, N and P applied together increased corn yields up to 169 bu/a. Maximum yield was obtained with 160 lb/a N with 80 lb/a P_2O_5 . Corn yields in 2018 (averaged across all N rates) were 9 bu/a greater with 80 than with 40 lb/a P_2O_5 .

The 10-year average grain N concentration (%) increased with N rates but tended to decrease when P was also applied, presumably because of higher grain yields diluting N content (Table 2). Grain N content reached a maximum of 0.6 lb/bu. N removal (lb/a) was greater at the higher yield levels. Maximum N removal (lb/a), was attained with 200 lb N and 80 lb P_2O_5 /a. At the highest N and P rate, $AFNR_g$ was 43% and $AFPR_g$ was 62%. Similar to N, average P concentration increased with increased P rates but decreased with higher N rates. Grain P content (lb/bu) of about 0.15 lb P/bu (0.34 lb P_2O_5 /bu) was greater at the highest P rate with low N rates. Grain P removal averaged 27 lb P/a at the highest yields.

Acknowledgment

The International Plant Nutrition Institute partially supported this research project.

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2009-2018

Fertilizer		Yield										Mean
N	P ₂ O ₅	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
----- lb/a -----		----- bu/a -----										
0	0	85	20	92	86	70	86	92	74	44	82	73
0	40	110	21	111	85	80	95	103	78	47	93	82
0	80	106	28	105	94	91	98	104	86	52	99	86
40	0	108	23	114	109	97	106	113	105	60	110	94
40	40	148	67	195	138	125	153	164	145	92	160	139
40	80	159	61	194	135	126	149	162	135	90	159	137
80	0	123	34	136	128	112	117	131	118	70	117	109
80	40	179	85	212	197	170	187	195	196	132	212	176
80	80	181	90	220	194	149	179	193	193	129	207	173
120	0	117	28	119	134	114	115	124	109	62	102	102
120	40	202	90	222	213	204	213	212	212	142	218	193
120	80	215	105	225	211	194	216	216	223	162	243	201
160	0	139	49	157	158	122	128	144	142	84	139	126
160	40	210	95	229	227	199	211	215	226	154	230	200
160	80	223	95	226	239	217	233	216	238	165	251	210
200	0	155	65	179	170	139	144	162	159	114	158	146
200	40	207	97	218	225	198	204	214	216	148	231	196
200	80	236	104	231	260	220	238	221	235	174	243	216

continued

Table 1. Nitrogen (N) and phosphorus (P) fertilization on irrigated corn yields, Tribune, KS, 2009-2018

Fertilizer		Yield										Mean
N	P ₂ O ₅	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
----- lb/a -----		----- bu/a -----										
ANOVA (P>F)												
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
MEANS												
Nitrogen, lb/a												
0		100 e	23 e	103 d	88 f	80 e	93 e	100 e	79 e	48 e	91 d	81 e
40		138 d	50 d	167 c	127 e	116 d	136 d	146 d	129 d	81 d	143 c	123 d
80		161 c	70 c	189 b	173 d	143 c	161 c	173 c	169 c	110 c	179 b	153 c
120		178 b	74 bc	189 b	186 c	171 b	181 b	184 b	182 b	122 b	188 b	165 b
160		191 a	80 ab	204 a	208 b	179 ab	190 ab	192 ab	202 a	134 a	207 a	179 a
200		199 a	89 a	209 a	218 a	186 a	196 a	199 a	203 a	145 a	211 a	186 a
LSD _(0.05)		12	9	13	10	10	10	9	10	11	13	8
P ₂ O ₅ , lb/a												
0		121 c	36 b	133 b	131 c	109 b	116 c	128 b	118 b	72 c	118 c	108 c
40		176 b	76 a	198 a	181 b	163 a	177 b	184 a	179 a	119 b	191 b	164 b
80		187 a	81 a	200 a	189 a	166 a	186 a	185 a	185 a	129 a	200 a	171 a
LSD _(0.05)		9	7	9	7	7	7	6	7	8	9	6

*Note: Hail events on 7/23/10, 5/28/15, and 8/18/17.

ANOVA = analysis of variance.

LSD = least significant difference.

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2009-2018

Fertilizer		Grain				Grain removal			
N	P ₂ O ₅	N	P	N	P	N	P	*AFNR _g	*AFPR _g
----- lb/a -----		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
0	0	0.98	0.226	0.46	0.107	33	8	---	---
0	40	0.94	0.304	0.44	0.144	36	12	---	23
0	80	0.94	0.317	0.45	0.150	37	13	---	15
40	0	1.16	0.181	0.55	0.086	51	8	45	---
40	40	0.96	0.299	0.45	0.141	62	20	73	67
40	80	0.97	0.318	0.46	0.151	62	21	72	37
80	0	1.26	0.177	0.59	0.084	63	9	38	---
80	40	1.04	0.251	0.49	0.119	86	21	67	73
80	80	1.01	0.305	0.48	0.145	82	25	61	49
120	0	1.27	0.171	0.60	0.081	61	8	23	---
120	40	1.13	0.225	0.53	0.107	102	20	58	71
120	80	1.09	0.295	0.52	0.139	103	28	58	57
160	0	1.25	0.175	0.59	0.083	74	10	25	---
160	40	1.17	0.240	0.55	0.114	110	22	48	83
160	80	1.15	0.276	0.55	0.131	114	27	51	55
200	0	1.22	0.188	0.58	0.089	83	13	25	---
200	40	1.18	0.235	0.56	0.111	108	22	38	79
200	80	1.17	0.291	0.55	0.138	119	30	43	62

continued

Table 2. Nitrogen (N) and phosphorus (P) fertilization on grain N and P content of irrigated corn, Tribune, KS, 2009-2018

Fertilizer		Grain				Grain removal			
N	P ₂ O ₅	N	P	N	P	N	P	*AFNR _g	*AFPR _g
----- lb/a -----		----- % -----		----- lb/bu -----		----- lb/a -----		----- % -----	
ANOVA (P>F)									
Nitrogen		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	---	0.001
Phosphorus		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Linear		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
Quadratic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	---
N × P		0.001	0.001	0.001	0.001	0.001	0.001	0.043	0.094
MEANS									
Nitrogen, lb/a									
0		0.95 e	0.282 a	0.45 e	0.134 a	35 e	11 e	---	19 d
40		1.03 d	0.266 b	0.49 d	0.126 b	58 d	16 d	63 a	52 c
80		1.10 c	0.244 c	0.52 c	0.116 c	77 c	18 c	55 b	61 b
120		1.16 b	0.230 d	0.55 b	0.109 d	88 b	19 bc	46 c	64 ab
160		1.19 a	0.231 d	0.56 a	0.109 d	99 a	20 ab	41 c	69 ab
200		1.19 a	0.238 cd	0.56 a	0.113 cd	103 a	21 a	35 d	70 a
LSD _(0.05)		0.02	0.011	0.01	0.005	4	1	5	9
P ₂ O ₅ , lb/a									
0		1.19 a	0.186 c	0.56 a	0.088 c	61 b	9 c	31 b	---
40		1.07 b	0.259 b	0.51 b	0.123 b	84 a	19 b	57 a	66 a
80		1.05 b	0.300 a	0.50 b	0.142 a	86 a	24 a	57 a	46 b
LSD _(0.05)		0.01	0.008	0.01	0.004	3	1	4	5

*AFNR_g and AFPR_g = Apparent Fertilizer N Recovery (grain) and Apparent Fertilizer P Recovery (grain).

ANOVA = analysis of variance.

LSD = least significant difference.